

FINAL REPORT  
MAY 1997

REPORT NO. 97-10

BRADLEY FIGHTING VEHICLE (BFV)  
ARMOR TILE WOODEN BOX  
MIL-STD-1660 TESTS

19980415 069

Prepared for:  
U.S. Army Armament Research, Development  
and Engineering Center  
ATTN: AMSTA-AR-ESK  
Rock Island, IL 61299-7300

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VALIDATION ENGINEERING DIVISION  
SAVANNA, ILLINOIS 61074-9639

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|   |       |  |   |   |                                 |
|   |       |  |   |   |                                 |
| 19. ABSTRACT (Continue on reverse if necessary and identify by block number)<br><br>The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SIOAC-DEV), was tasked by U.S. Army Armament Research, Development and Engineering Center (ARDEC) to conduct MIL-STD-1660 tests on the unitization procedures for armor tile wooden boxes. There was no damage to the armor tile wooden boxes as a result of these tests; therefore, it meets the requirements for MIL-STD-1660, Design Criteria for Ammunition Unit Loads. |       |  |   |   |                                 |
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U.S. ARMY DEFENSE AMMUNITION CENTER  
VALIDATION ENGINEERING DIVISION  
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REPORT NO. 97-10

BRADLEY FIGHTING VEHICLE (BFV) ARMOR TILE WOODEN BOX  
MIL-STD-1660 TESTS

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## PART 1

### INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SIOAC-DEV), was tasked by U.S. Army Armament Research, Development and Engineering Center (ARDEC) to conduct MIL-STD-1660 tests on the unitization procedures for armor tile wooden boxes.

B. AUTHORITY. This test was conducted IAW mission responsibilities delegated by the U.S. Army Armament, Munitions and Chemical Command (AMCCOM), Rock Island, Illinois.

C. OBJECTIVE. The objective of these tests was to determine whether the unitization procedures for armor tile wooden boxes was capable of meeting MIL-STD-1660, Design Criteria for Ammunition Loads, requirements.

D. CONCLUSION. The unitization procedures for the armor tile wooden boxes as tested met MIL-STD-1660, Design Criteria for Ammunition Loads, requirements.

PART 2

2 - 6 MAY 1997

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## PART 3

### TEST PROCEDURES

The test procedures outlined in this section were extracted from MIL-STD-1660, Design Criteria for Ammunition Unit Loads, 8 April 1977. This standard identifies nine steps that a unitized load must undergo if it is to be considered acceptable. The four tests that were conducted on the test pallets are summarized below.

A. STACKING TEST. The unit load was loaded to simulate a stack of identical unit loads stacked 16 feet high, for a period of one hour. This stacking load was simulated by subjecting the unit load to a compression weight equal to an equivalent 16-foot stacking height. The compression load was calculated in the following manner. The unit load weight was divided by the unit load height in inches and multiplied by 192. The resulting number was the equivalent compressive force of a 16-foot-high load.

B. REPETITIVE SHOCK TEST. The repetitive shock test was conducted IAW Method 5019, Federal Standard 101. The test procedure is as follows: The test specimen was placed on, but not fastened to, the platform. With the specimen in one position, the platform was vibrated at 1/2-inch amplitude (1-inch double amplitude) starting at a frequency of approximately 3 cycles per second. The frequency was steadily increased until the package left the platform. The resonant frequency was achieved when a 1/16-inch-thick feeler gage momentarily slid freely between every point on the specimen in contact with the platform at some instance during the cycle or a platform acceleration achieved  $1 \pm 0.1$  Gs. Midway into the testing period, the specimen was rotated 90 degrees and the test continued for the duration. Unless failure occurred, the total time of vibration was two hours if the specimen was tested in one position and three hours for more than one position.

C. EDGEWISE ROTATIONAL DROP TEST. This test was conducted using the procedures of Method 5008, Federal Standard 101. The procedure for the edgewise rotational drop test is as follows: The specimen was placed on its skids with one end of the pallet supported on a beam 4-1/2 inches high. The height of the beam was increased, if necessary, to ensure that there was no support for the skids between the ends of the pallet when dropping took place, but was not high enough to cause the pallet to slide on the supports when the dropped end was raised for the drops. The unsupported end of the pallet was then raised and allowed to fall freely to the concrete, pavement, or similar underlying surface from a prescribed height. Unless otherwise specified, the height of drop for level A protection conforms to the following tabulation:

| GROSS WEIGHT<br>(WITHIN RANGE<br>LIMITS)<br>(Pounds) | DIMENSIONS OF<br>ANY EDGE, HEIGHT<br>OR WIDTH (WITHIN<br>RANGE LIMITS)<br>(Inches) | HEIGHT OF DROPS<br>ON EDGES |                     |
|--|--|-----------------------------|---------------------|
|  |  | Level A<br>(Inches)         | Level B<br>(Inches) |
| 150 - 250  | 60 - 66  | 36                          | 27                  |
| 250 - 400  | 66 - 72  | 32                          | 24                  |
| 400 - 600  | 72 - 80  | 28                          | 21                  |
| 600 - 1000   | 80 - 95  | 24                          | 18                  |
| 1000 - 1500  | 95 - 114   | 20                          | 16                  |
| 1500 - 2000  | 114 - 144  | 17                          | 14                  |
| 2000 - 3000  | Above 145 - No limit   | 15                          | 12                  |
| Above - 3000   |  | 12                          | 9                   |

D. INCLINE-IMPACT TEST. This test was conducted by using the procedure of Method 5023, Incline-Impact Test of Federal Standard 101. The procedure for the incline-impact test is as follows: The specimen was placed on the carriage with the surface or edge which is to be



impacted projecting at least 2 inches beyond the front end of the carriage. The carriage was brought to a predetermined position on the incline and released. If it is desired to concentrate the impact on any particular position on the container, a 4- by 4-inch timber was attached to the bumper in the desired position before the test. No part of the timber was struck by the carriage. The position of the container on the carriage and the sequence in which surfaces and edges are subjected to impacts was at the option of the testing activity and depends upon the objective of the tests. This test is to determine satisfactory requirements for a container or pack, and, unless otherwise specified, the specimen was subjected to one impact on each surface that has each dimension less than 9.5 feet. Unless otherwise specified, the velocity at time of impact was 7 feet per second.

## PART 4

### TEST EQUIPMENT

#### A. Pallet (Test Sample).

- |                          |                      |
|--------------------------|----------------------|
| 1. Width:                | 38-5/8 inches        |
| 2. Length:               | 46-7/8 inches        |
| 3. Unit Load Height:     | 52 inches            |
| 4. Unit Load Weight:     | 2,230 pounds         |
| 5. Wooden Box Restraint: | Intermediate Banding |

#### B. Compression Tester.

- |                       |                      |
|-----------------------|----------------------|
| 1. Manufacturer:      | Ormond Manufacturing |
| 2. Platform:          | 60- by 60-inches     |
| 3. Compression Limit: | 50,000 pounds        |
| 4. Tension Limit:     | 50,000 pounds        |

#### C. Transportation Simulator.

- |                  |                    |
|------------------|--------------------|
| 1. Manufacturer: | Gaynes Laboratory  |
| 2. Capacity:     | 6,000 pounds       |
| 3. Displacement: | 1/2-inch amplitude |
| 4. Speed:        | 50 to 400 rpm      |
| 5. Platform:     | 5- by 8-foot       |

#### D. Inclined Plane.

- |                  |                    |
|------------------|--------------------|
| 1. Manufacturer: | Conbur Incline     |
| 2. Type:         | Impact Tester      |
| 3. Grade:        | 10 percent incline |
| 4. Length:       | 12-foot            |

## PART 5

### TEST RESULTS

A. TEST OBSERVATIONS. The test sample was loaded with armor tile boxes on a wooden pallet.

B. STACKING TEST. The test sample was initially loaded to 8,300 pounds compression. The compression was released after 1 hour. No damage was noted during this test.

C. REPETITIVE SHOCK TEST. The duration of the test was 90 minutes for each orientation of the pallet. The transportation simulator was operated at 218 rpm while the pallet was oriented in the lateral direction. For the longitudinal orientation, the transportation simulator was operated at 224 rpm. Slight load movement of less than 1 inch was observed. No damage was noted during this test.

D. EDGEWISE ROTATIONAL DROP TEST. One side of the pallet was placed on a beam displacing it 4-1/2 inches above the floor. The opposite end of the pallet was raised to a height of 15 inches, then dropped. The pallet was rotated clockwise after each impact until all four sides had been tested. No damage was noticed after dropping the pallet from a height of 15 inches on all four sides.

E. INCLINE-IMPACT TEST. The incline-plane was set to allow the pallet to travel 8 feet prior to impacting a stationary wall. The pallet was rotated clockwise after each impact, until all four sides had been tested. No damage was noticed on the pallet only slight shifting of the load was noticed.

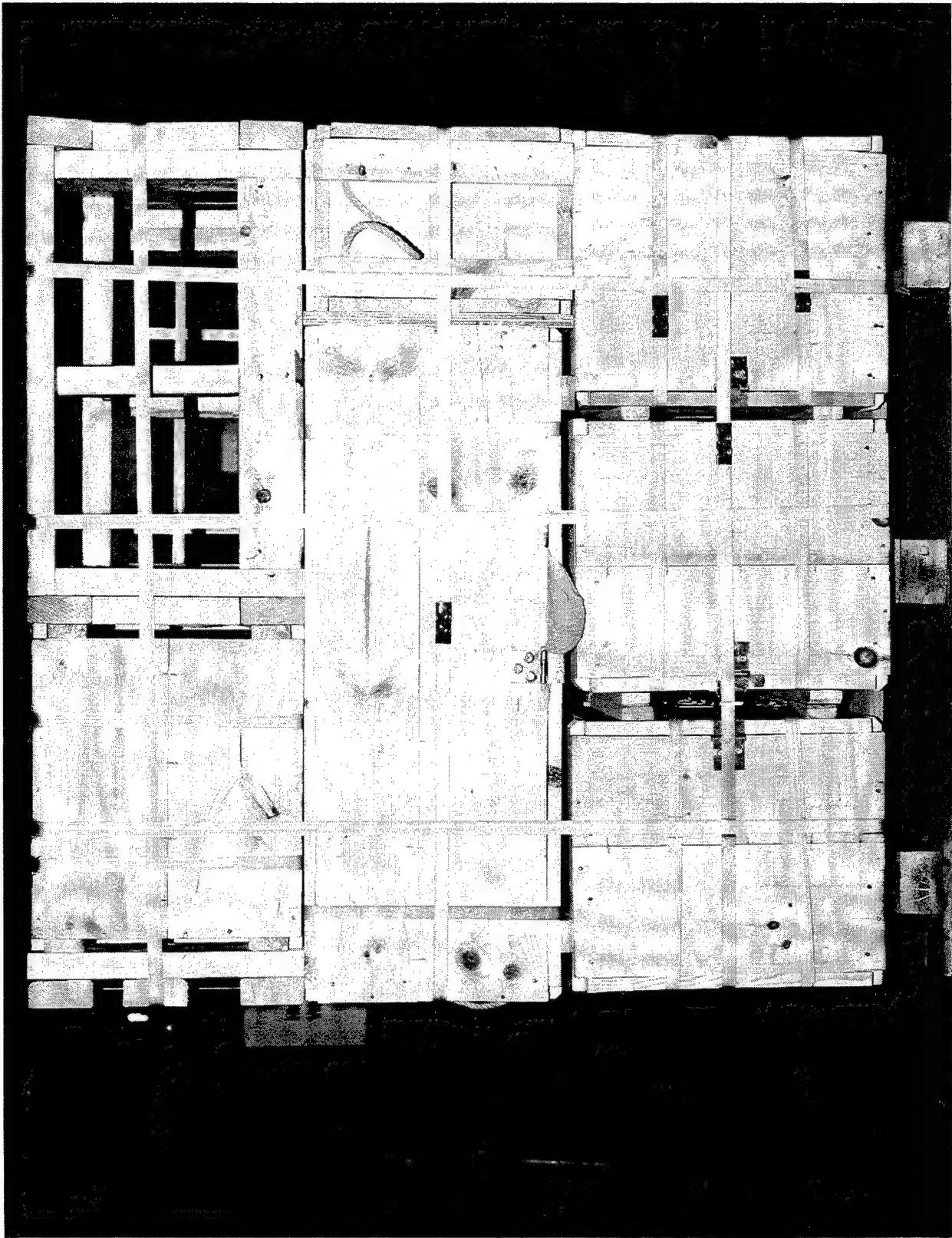
F. POST TEST INSPECTION. No major damage was noted at the end of testing. There was minor cracking of the dunnage at the end of the boxes and a 3-inch-wide piece of board broke off the top outside stringer board.

**PART 6**

**PHOTOGRAPHS**



|  |   |  |
|--|---|--|
|  | U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL -<br>SAVANNA, IL |  |
| AO317-SCN-97-2034. This photo shows a closeup view of the palletized load prior to MIL-STD-1660 tests. |   |  |



U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL -  
SAVANNA, IL

AO317-SCN-97-2035. This photo shows a side view of the palletized load after MIL-STD 1660 tests.

**PART 7**

**DRAWING**

# UNITIZATION PROCEDURES FOR ARMOR TILE COMBINATION PALLET, PACKED VARIOUS QUANTITIES IN VARIOUS WOODEN BOXES, UNITIZED 17 BOXES PER 35" X 45-1/2" PALLET; APPROX CONTAINER SIZE VARIES

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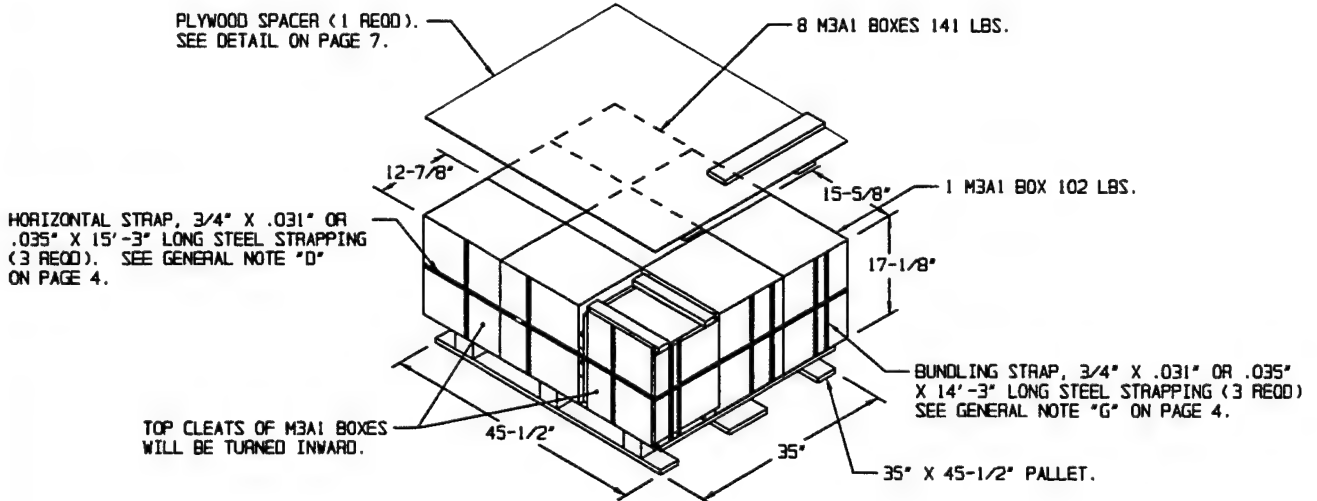
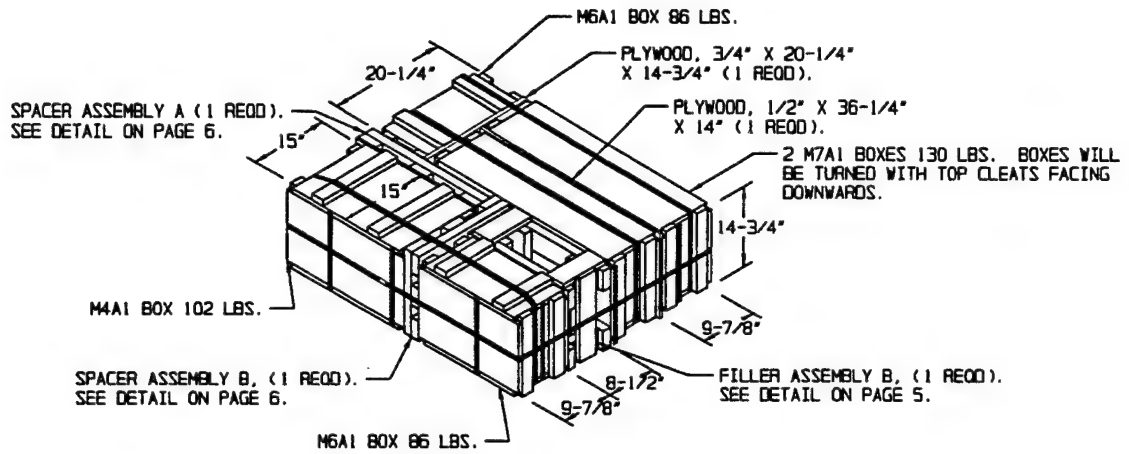
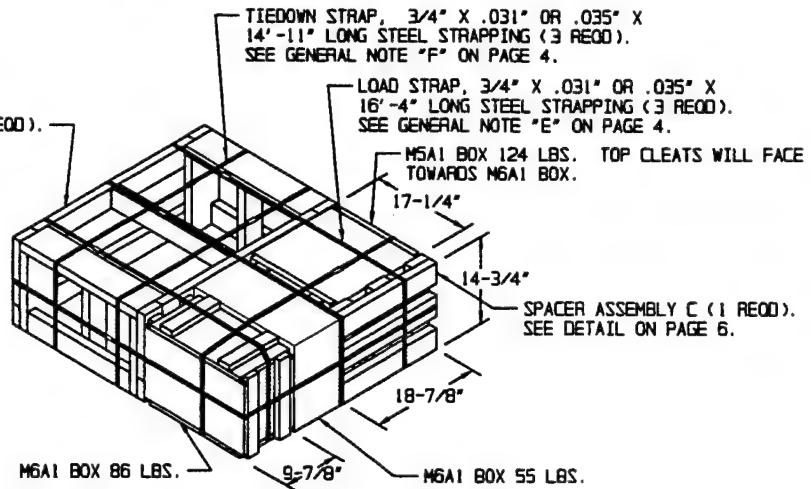
| U.S. ARMY MATERIEL COMMAND DRAWING   |  |  |  |                                |          |   |              |
|--|--|--|--|--------------------------------|----------|---|--------------|
| APPROVED, U.S. ARMY INDUSTRIAL OPERATIONS<br>COMMAND   |  |  |  | DRAFTSMAN                      |          | BETTY J. KUNDERT                          |              |
|  |  |  |  | ENGINEER                       |          | SANDRA M. SCHULTZ                         |              |
| <div style="display: flex; justify-content: space-between;"> <span>AMSTA-AR-ESK</span> <span>ANSIO-TMJ</span> </div> |  |  |  | SUPPLY ENGINEERING<br>DIVISION |          | TRANSPORTATION<br>ENGINEERING<br>DIVISION |              |
|  |  |  |  |                                |          | VALIDATION<br>ENGINEERING<br>DIVISION     |              |
| APPROVED BY ORDER OF COMMANDING GENERAL, U.S.<br>ARMY MATERIEL COMMAND   |  |  |  | LOGISTICS ENGINEERING OFFICE   |          |   |              |
|  |  |  |  | MAY 1997                       |          |   |              |
| U.S. ARMY DEFENSE AMMUNITION CENTER  |  |  |  | CLASS                          | DIVISION | DRAWING                                   | FILE         |
|  |  |  |  | 19                             | 48       | 4221/8                                    | 20PA<br>1009 |
|  |  |  |  |                                |          |   |              |



| PALLET UNIT DATA     |       |                             |            |                   |
|----------------------|-------|-----------------------------|------------|-------------------|
| ITEMS INCLUDED       |       | HAZARD CLASS AND DIVISION • |            | APPROX WEIGHT LBS |
| NSN                  | DODIC | DD CLASS                    | COMP GROUP |                   |
| ????--<br>??-??-???? | ????  | ?.?                         | ?          | 2,241             |

- HAZARD CLASSIFICATION DATA CONTAINED IN THE ABOVE CHART IS FOR GUIDANCE AND INFORMATIONAL PURPOSES ONLY. VERIFICATION OF THE SPECIFIED DATA SHOULD BE MADE BY CONSULTING THE MOST RECENT JOINT HAZARD CLASSIFICATION SYSTEM LISTING OR OTHER APPROVED LISTING(S).

FILLER ASSEMBLY A (1 REQD).  
SEE DETAIL ON PAGE 5.



#### PALLET UNIT

SEE GENERAL NOTE "B" ON PAGE 4.

|                   |       |                    |
|-------------------|-------|--------------------|
| 17 BOXES OF TILES | ----- | 2,029 LBS (APPROX) |
| DUNNAGE           | ----- | 147 LBS            |
| PALLET            | ----- | 65 LBS             |

TOTAL WEIGHT --- 2,241 LBS (APPROX)  
CUBE ----- 54.9 CU FT (APPROX)

OVERALL UNIT LOAD SIZE 46-7/8" L X 38-5/8" W X 52-3/8" H

## GENERAL NOTES

- A. THIS DOCUMENT HAS BEEN PREPARED AND ISSUED IN ACCORDANCE WITH AR740-1 AND AUGMENTS TM 743-200-1 (CHAPTER 5) AND CONFORMS TO MIL-STD-1660.
- B. DIMENSIONS, CUBE AND WEIGHT OF A PALLET UNIT WILL VARY SLIGHTLY DEPENDING UPON THE ACTUAL DIMENSIONS OF THE BOXES AND THE WEIGHT OF THE SPECIFIC ITEM BEING UNITIZED.
- C. CONVERSION TO METRIC EQUIVALENTS: DIMENSIONS WITHIN THIS DOCUMENT ARE EXPRESSED IN INCHES, AND WEIGHTS ARE EXPRESSED IN POUNDS. WHEN NECESSARY, THE METRIC EQUIVALENTS MAY BE COMPUTED ON THE BASIS OF ONE INCH EQUALS 25.4 MM AND ONE POUND EQUALS 0.454 KG.
- D. INSTALL EACH HORIZONTAL STRAP TO BE LOCATED AS SHOWN. HORIZONTAL STRAPS MUST BE TENSIONED AND SEALED PRIOR TO THE APPLICATION OF TIEDOWN AND LOAD STRAPS.
- E. THE LOAD STRAPS WILL NOT BE THREADED THROUGH THE STRAP SLOTS OF A PALLET. THE LOAD STRAPS MAY BE THREADED THROUGH THE CLEATS OF THE BOXES OR PRE-POSITIONED ON THE PALLET DECK PRIOR TO PLACING BOXES ON THE PALLET. LOAD STRAPS MUST BE TENSIONED PRIOR TO THE APPLICATION OF TIEDOWN STRAPS AND AFTER THE APPLICATION OF HORIZONTAL STRAPS.
- F. INSTALL EACH TIEDOWN STRAP TO PASS UNDER THE DECK BOARDS OF THE PALLET AND TO BE LOCATED AS SHOWN. TIEDOWN STRAPS WILL NOT BE APPLIED UNTIL THE LOAD STRAPS AND HORIZONTAL STRAPS HAVE BEEN TENSIONED AND SEALED.

G. INSTALL EACH BUNDLING STRAP TO ENCIRCLE THE BOTTOM TWO LAYERS OF BOXES AND FILLERS ON THE PALLET. THE BUNDLING STRAPS MAY BE THREADED THROUGH THE CLEATS OF THE BOXES OR PRE-POSITIONED ON THE PALLET DECK PRIOR TO PLACING BOXES ON THE PALLET. THE BUNDLING STRAPS WILL NOT BE THREADED THROUGH THE STRAP SLOTS OF THE PALLET. THE BUNDLING STRAPS MUST BE APPLIED BEFORE THE THIRD LAYER IS LOADED ONTO THE PALLET AND AFTER THE HORIZONTAL STRAPS ARE APPLIED TO THE FIRST AND SECOND LAYERS.

H. THE FOLLOWING AMC DRAWINGS ARE APPLICABLE FOR OUTLOADING AND STORAGE OF THE ITEMS COVERED BY THIS DRAWING.

CARLOADING - - - - 19-48-4115-5PA1002  
 TRUCKLOADING - - - - 19-48-4117-11PA1003  
 STORAGE - - - - - 19-48-4118-1-2-3-4-14-22PA1002  
 END OPENING ISO  
 CONTAINER - - - - - 19-48-4153-15PA1002  
 MILVAN - - - - - 19-48-4166-15PA1003  
 SIDE OPENING ISO  
 CONTAINER - - - - - 19-48-4267-15PA1009

J. IF ITEMS COVERED HEREIN ARE UNITIZED PRIOR TO ISSUANCE OF THIS DRAWING, THE BOXES NEED NOT BE REUNITIZED SOLELY TO CONFORM TO THIS DRAWING.

K. THE UNITIZATION PROCEDURES DEPICTED HEREIN MAY ALSO BE USED FOR UNITIZING ARMOR TILE WHEN IDENTIFIED BY DIFFERENT NATIONAL STOCK NUMBERS (NSN) THAN WHAT IS SHOWN ON PAGE 2, PROVIDED THE BOX PACK DOES NOT VARY FROM WHAT IS DELINEATED HEREIN. THE EXPLOSIVE CLASSIFICATION OF OTHER ITEMS MAY BE DIFFERENT THAN WHAT IS SHOWN.

L. THE STYLE 1A PALLET DELINEATED IN THE DETAIL ON PAGE 3 NEED NOT HAVE CHAMFERS OR STRAP SLOTS AS SPECIFIED WITHIN MILITARY SPECIFICATION MIL-P-15011 WHEN USED FOR THE UNITIZATION OF ITEMS COVERED BY THIS DRAWING.

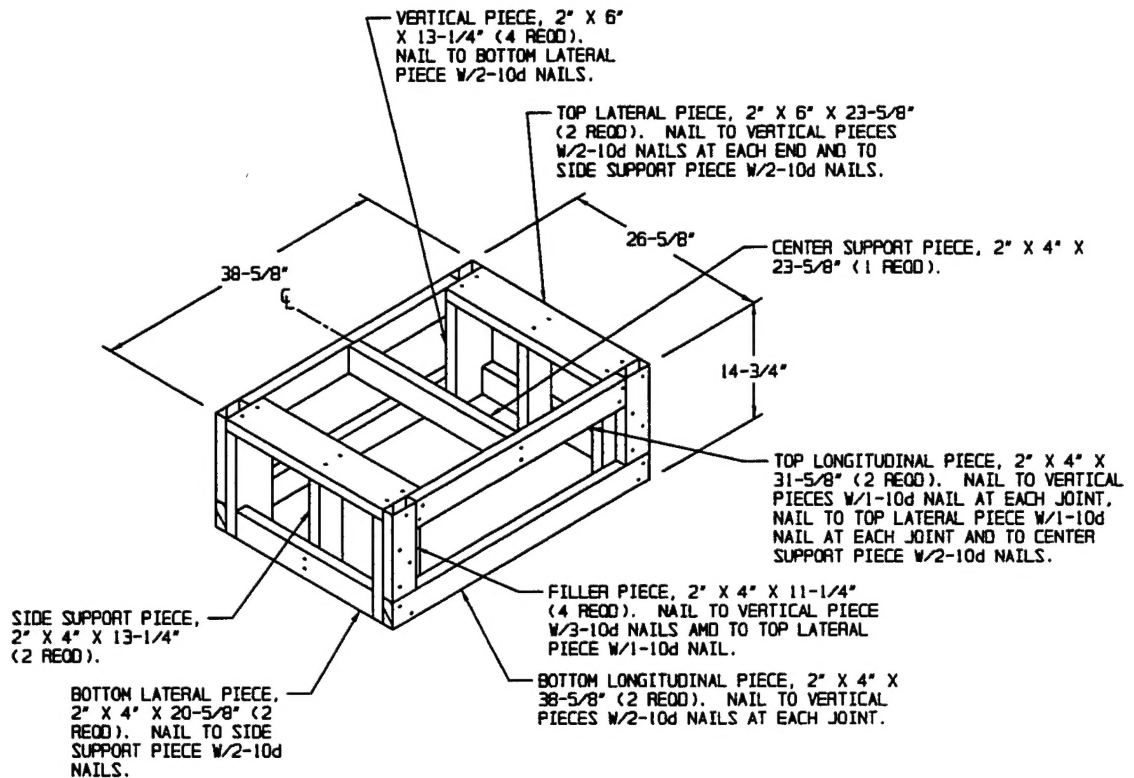
M. ALL DUNNAGE, SUCH AS FILLER OR SPACER ASSEMBLIES, USED IN UNIT LOADS SHALL BE PRESERVATIVE TREATED IN ACCORDANCE WITH THE PROCEDURES SPECIFIED IN MIL-B-2427 FOR CLEATED WOODEN BOXES. IF THE DUNNAGE CONSISTS OF MORE THAN ONE COMPONENT, IT MUST BE ASSEMBLED PRIOR TO TREATMENT. THE LETTERS PA DENOTING P056 (COPPER-8-QUINOLINOLATE), PB DENOTING M-GARD W550 (ZINC NAPHTHENATE EMULSIFIABLE) OR PC DENOTING M-GARD W510 OR CUNAPSOL 5 (COPPER NAPHTHENATE) MUST BE APPLIED TO THE WOOD DUNNAGE IN LETTERS AT LEAST ONE INCH HIGH.

N. THE WOODEN BOXES ARE MIL-STD-2427 BOXES. FOR DETAILS OF THE M3A1 BOX SEE DRAWING 12590204, FOR THE M4A1 BOX SEE 12561423, FOR THE M5A1 BOX SEE 12590209, FOR THE M6A1 BOX SEE 12590330 AND FOR THE M7A1 BOX SEE 12590323.

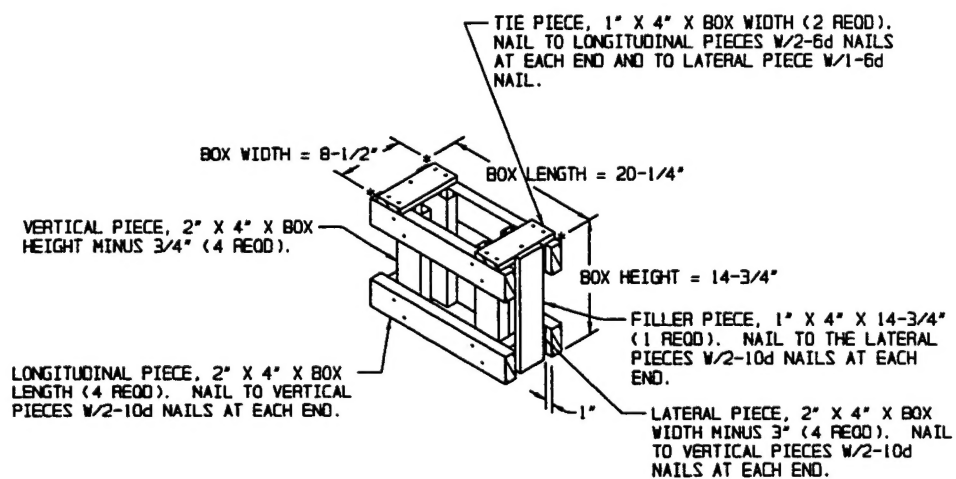
## MATERIAL SPECIFICATIONS

- PALLET - - - - - : MIL SPEC MIL-P-15011; 4-WAY ENTRY, STYLE 1A, TYPE I, CLASS I, PRESERVATIVE TREATED.
- LUMBER - - - - - : SEE TM 743-200-1 (DUNNAGE LUMBER) AND FED SPEC MM-L-751.
- NAILS - - - - - : ASTM F1667; COMMON STEEL NAIL (NLCMS OR NLCMS). ALT: UNDERLAYMENT NAIL (NLUL), PALLET NAIL (NLPL), OR COOLER NAIL (NLCL) OF SAME SIZE.
- PLYWOOD - - - - - : COMMERCIAL ITEM DESCRIPTION A-A-55057, TYPE A, CONSTRUCTION AND INDUSTRIAL PLYWOOD, INTERIOR WITH EXTERIOR GLUE, GRADE C-D. IF SPECIFIED GRADE IS NOT AVAILABLE, A BETTER INTERIOR OR AN EXTERIOR GRADE MAY BE SUBSTITUTED.
- STRAPPING, STEEL - - : ASTM D3953; FLAT STRAPPING, TYPE I, HEAVY DUTY, FINISH B (GRADE 2), SIZE 3/4" X .035" OR .031".
- SEAL, STRAP - - - - : ASTM D3953; CLASS H, FINISH B (GRADE 2), DOUBLE NOTCH TYPE, STYLE I, II, OR IV.
- STAPLE - - - - - : ASTM F1667; 15/16" OR 1" CROWN WIDTH X 3/4" LEG LENGTH FOR 3/4" STRAPPING, TYPE IV, STYLE 3.

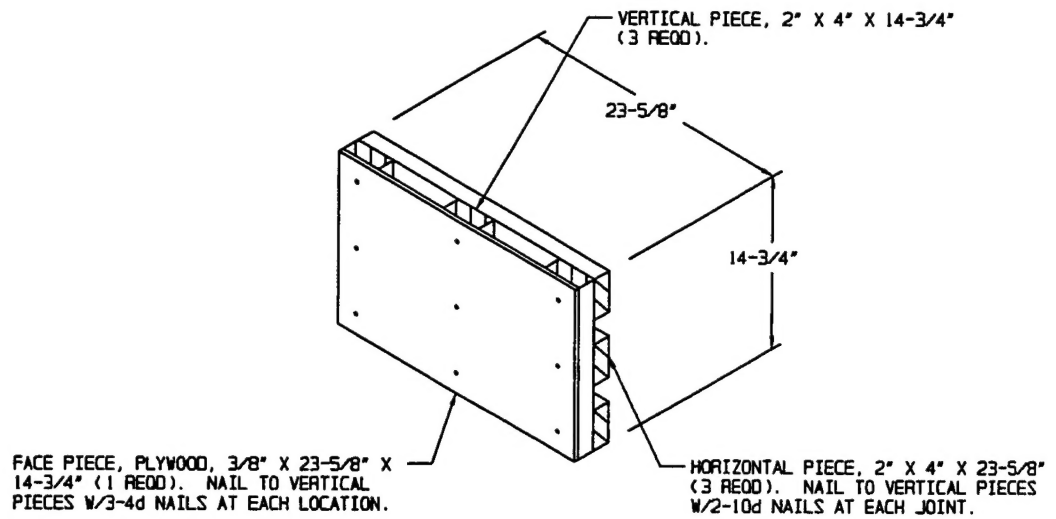
| BILL OF MATERIAL   |             |            |
|--|-------------|------------|
| LUMBER   | LINEAR FEET | BOARD FEET |
| 1" X 4"  | 10.83       | 3.61       |
| 2" X 4"  | 62.60       | 41.73      |
| 2" X 6"  | 8.35        | 8.35       |
| NAILS  | NO. REQD    | POUNDS     |
| 4d (1-1/2")  | 34          | 0.12       |
| 6d (2")  | 10          | 0.06       |
| 10d (3")   | 142         | 2.18       |
| PALLET, 35" X 45-1/2" - - - - - 1 REQD - - - 65 LBS          |             |            |
| STEEL STRAPPING, 3/4" - - - - - 182.25' REQD - - - 16.27 LBS |             |            |
| SEAL FOR 3/4" STRAPPING - - - - - 12 REQD - - - NIL          |             |            |
| PLYWOOD, 1/4" - - - - - 12.43 SQ FT REQD - - - 8.55 LBS      |             |            |
| PLYWOOD, 3/8" - - - - - 2.42 SQ FT REQD - - - 2.50 LBS       |             |            |
| PLYWOOD, 1/2" - - - - - 3.52 SQ FT REQD - - - 4.84 LBS       |             |            |
| PLYWOOD, 3/4" - - - - - 2.07 SQ FT REQD - - - 4.27 LBS       |             |            |



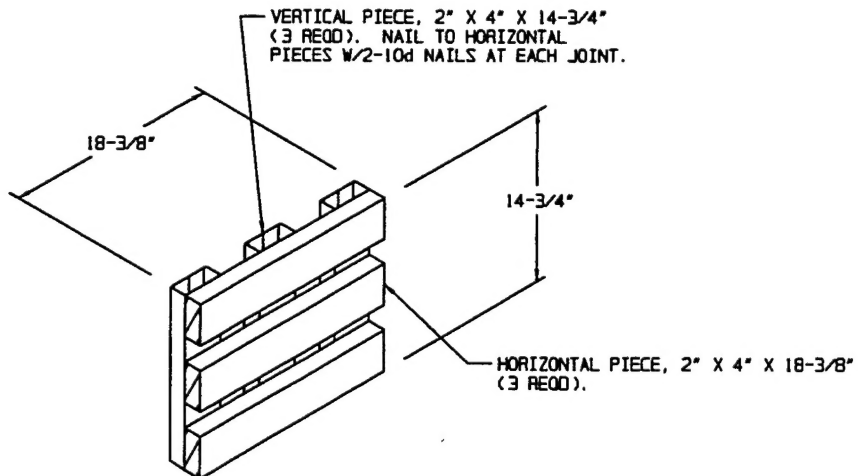
FILLER ASSEMBLY A



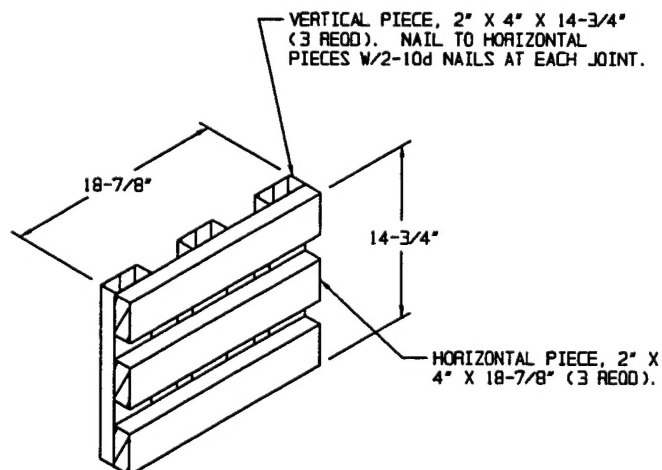
FILLER ASSEMBLY B



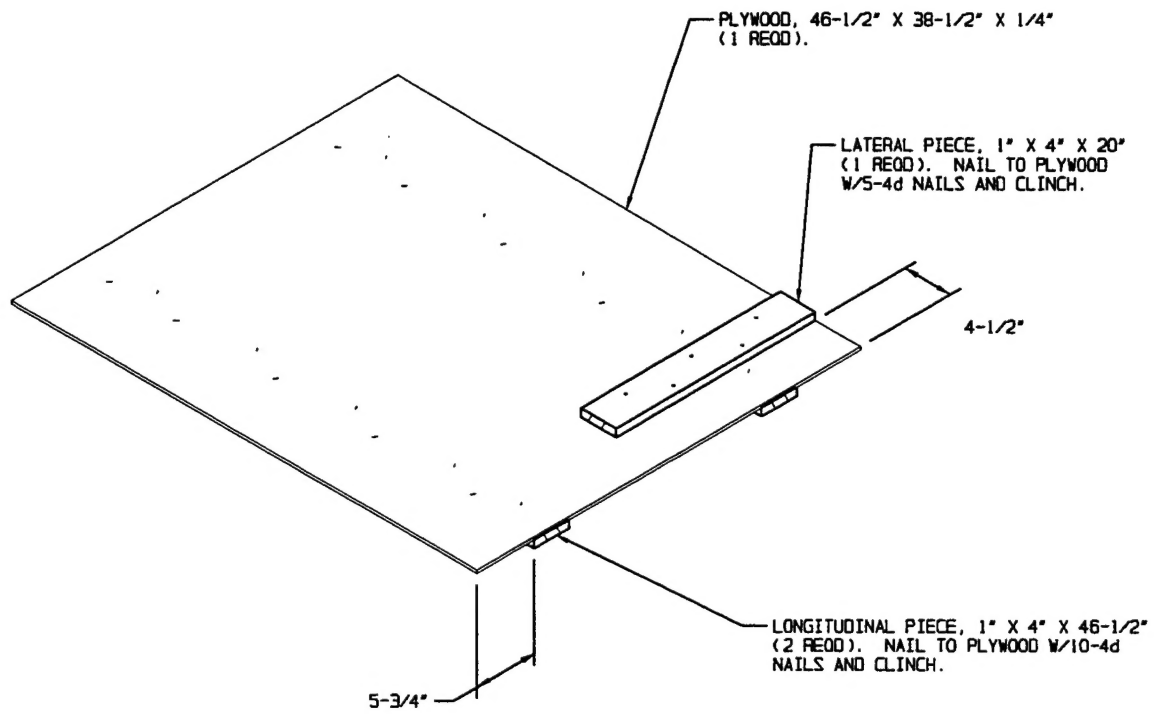
SPACER ASSEMBLY A



SPACER ASSEMBLY B



SPACER ASSEMBLY C



PLYWOOD SPACER